Dirac and Weyl Fermions in Strained Grey-Sn films on Hybrid CdTe/GaAs (001) Substrate

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Grey-tin (a-Sn), the low-temperature allotrope of tin with a diamond structure, is a promising platform for exploring topological phases and applications in quantum technologies [1]. However, conventional narrow-gap InSb substrates, commonly used to stabilize a-Sn at room temperature, introduce parallel conduction effects that hinder detailed transport studies and limit practical applications.
This study overcomes above-mentioned challenges by achieving the MBE growth of high-quality a-Sn films, with thickness ranging from 30 to 200 nm, on insulating CdTe/GaAs(001) substrates. The structural and morphological investigations reveal the formation of a smooth coherent Sn/CdTe interface and the stability of diamond structure of tin at 300 K. Compressive in-plane strain of $\varepsilon_{//}$ = -0.14 % is detected enabling further investigations of strain-induced 3D Dirac semimetal (DSM) and magnetic field-induced Weyl semimetal (WSM) phases. A combined approach of magneto-optical experiments and band structure $k{\cdot}p$ modeling provides a detailed characterization of the bulk states in the DSM phase. Key band structure parameters, such as the inverted energy gap (E_g = -415 meV) and the distance between two Dirpac points (Δk_D = 0.018 Å^{-1}), have been determined. Angle-resolved photoemission spectroscopy (ARPES) further confirms the presence of both bulk and surface states associated with the DSM phase. Additionally, these films exhibit high bulk electron mobility, reaching 20,000 cm^2/(V·s), creating favorable conditions for exploring quantum transport. The study also investigates negative longitudinal magnetoresistance, linking it to the chiral anomaly—a hallmark of WSMs. The π Berry phase observed in Shubnikov-de Haas oscillations further supports the material's non-trivial topology [2]. These findings establish a-Sn films on insulating substrates as a robust platform for studying relativistic effects and advancing topological and spintronic devices.

References

[1] L.D. Anh, K. Ishihara, et al., Nat. Commun. 15 (2024) 8014
[2] X J. Polaczyński, G. Krizman, et al., Materials Today 75 (2024) 135

Figures

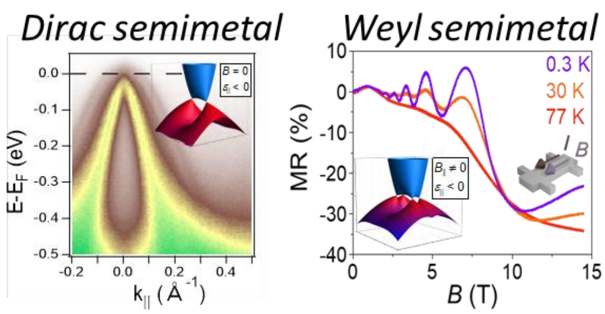

Figure 1: DSM and WSM phases measured by ARPES and observed by magneto-transport respectively